2017

Industrial Grain Hemp Variety Trial

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UNIVERSITY OF VERMONT EXTENSION
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2017 INDUSTRIAL GRAIN HEMP VARIETY TRIAL

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Hemp is a non-psychoactive variety of *cannabis sativa L*. The crop is one of historical importance in the U.S. and reemerging in worldwide importance as manufacturers seek hemp as a renewable and sustainable resource for a wide variety of consumer and industrial products. The crop produces a valuable oilseed, rich in Omega-3 and other essential fatty acids that are often absent in western diets. When the oil is extracted from the seed, what remains is a marketable meal co-product, which is used for human and animal consumption. The fiber has high tensile strength and can be used to create cloth, rope, building materials, and even a form of plastic. For twenty years, U.S. entrepreneurs have been importing hemp from China, Eastern Europe and Canada to manufacture travel gear, apparel and accessories, body care and cosmetics, foods like bread, beer, and salad oils, paper products, building materials and animal bedding, textiles, auto parts, housewares, and sporting equipment. Industrial hemp is poised to be a “new” cash crop and market opportunity for Vermont farms that is nutritious, versatile, and suitable for rotation with other small grains and grasses.

To help farmers succeed, agronomic research on hemp is needed, as much of the historical production knowledge for the region has been lost. In this trial, we evaluated hemp grain varieties to determine best cultivars for the region.

MATERIALS AND METHODS

Table 1. Agronomic information for the industrial hemp grain variety trial 2017, Alburgh, VT.

Location	**Borderview Research Farm Alburgh, VT**
Soil type	Covington silty clay loam, 0-3% slope
Previous crop	Dry beans
Plot size (ft)	5x20
Planting date	26-May
Emergence date	9-Jun
Row spacing	7”
Planting equipment	Great Plains NT60 Cone Seeder
Planting rate (live seeds m^{-2})	125
Harvest date	13-Sep

The trial was conducted at Borderview Research Farm in Alburgh, Vermont (Table 1) to evaluate the impact variety has on hemp grain yield. The experimental design was a randomized complete block with four replications. Twelve grain varieties (Table 2) were planted on 26-May for the trial. Seeding rates were adjusted after accounting for germination rates and a mortality rate of 30%, to a target of 125 live seeds m^{-2}. The typical seeding rate used by hemp grain growers is ~25 lbs ac^{-1}.

Table 2. Hemp grain varieties evaluated in the hemp trial 2017, Alburgh, VT.

Variety	Seed company	Days to maturity
CFX-2	Hemp Genetics International	100-110
CRS-1	Hemp Genetics International	100-110
Grandi	Hemp Genetics International	100-110
Katani	Hemp Genetics International	100-110
Canda	Parkland Industrial Hemp Growers	100-120
Delores	Parkland Industrial Hemp Growers	100-120
Fedora 17	Schiavi Seeds	120
Helena	Schiavi Seeds	150
Tygra	Schiavi Seeds	120
USO 31	Schiavi Seeds	90-100
Anka	Valley Bio Limited	110
Full Sun	---	---

Table 3. Participating seed companies and contact information.

Hemp Genetics International	Parkland Industrial Hemp Growers	Schiavi Seeds	Valley Bio Limited
Jeff Kostuik Saskatoon, Saskatchewan (204) 821-0522 Jeff.kostuik@hempgenetics.com	Clare Dutchysen Dauphin, Manitoba (204) 629-4367 info@pihg.net	Andrea Schiavi Lexington, Kentucky info@schiaviseeds.com	Reuben Stone Cobden, Ontario (613) 646-9737 info@valleybio.com

Seed was sourced from four seed companies (Table 3). The trial was planted into 5’x20’ plots. On 6-Jul, the trial was fertilized with 100 lbs ac^{-1} of nitrogen, 60 lbs ac^{-1} of phosphorus, and 60 lbs ac^{-1} of potassium. Fertility amendments were based on soil test results. All fertility amendments were approved for use in organic systems.

Two to three weeks after planting, vigor was measured by doing a visual assessment of each plot and using a 1=low through 5=high scale. A month after each planting, plant populations were recorded by counting the number of plants in a foot-long section of a row, three times per plot. A few days before harvest, data was collected on plant heights by measuring three randomly selected plants per plot. Infection rates from the disease *Sclerotinia sclerotiorum* were recorded 1.5 months after planting, at female flower development stage, and just before harvest by counting the number of infected plants per plot. Pest pressure from arthropods was recorded at those times as well, by counting the number and variety of each arthropod present on two leaves from five plants per plot. On 13-Sep the grain plots were harvested using an Almaco SPC50 small plot combine. Test weight was also measured using a Berckes

Test Weight Scale, which weighs a known volume of grain. Harvest moisture was calculated by using an OHaus (Parsippany, New Jersey) MB 23 moisture analyzer.

The data was analyzed using mixed model analysis using the mixed procedure of SAS (SAS Institute, 1999). Replications within trials were treated as random effects, and varieties were treated as fixed. Mean comparisons were made using the Least Significant Difference (LSD) procedure when the F-test was considered significant ($p<0.10$).

Variations in yield and quality can occur because of variations in genetics, soil, weather, and other growing conditions. Statistical analysis makes it possible to determine whether a difference among treatments is real or whether it might have occurred due to other variations in the field. At the bottom of each table a LSD value is presented for each variable (i.e. yield). Least Significant Differences (LSDs) at the 0.10 level of significance are shown, except where analyzed by pairwise comparison (t-test). Where the difference between two treatments within a column is equal to or greater than the LSD value at the bottom of the column, you can be sure that for 9 out of 10 times, there is a real difference between the two treatments. Treatments that were not significantly lower in performance than the top-performing treatment in a particular column are indicated with an asterisk. In this example, hybrid C is significantly different from hybrid A but not from hybrid B. The difference between C and B is equal to 1.5, which is less than the LSD value of 2.0. This means that these hybrids did not differ in yield. The difference between C and A is equal to 3.0, which is greater than the LSD value of 2.0. This means that the yields of these hybrids were significantly different from one another. The asterisk indicates that hybrid B was not significantly lower than the top yielding hybrid C, indicated in bold.

Treatment	Yield
A	6.0
B	7.5*
C	**9.0***
LSD	2.0

RESULTS

Seasonal precipitation and temperature were recorded with a Davis Instrument Vantage Pro2 weather station, equipped with a WeatherLink data logger at Borderview Research Farm in Alburgh, VT.

Table 4. Seasonal weather data collected in Alburgh, VT, 2017.

Alburgh, VT	May	June	July	August	September
Average temperature (°F)	55.7	65.4	68.7	67.7	64.4
Departure from normal	-0.75	-0.39	-1.90	-1.07	3.76
Precipitation (inches)	4.10	5.60	4.90	5.50	1.80
Departure from normal	0.68	1.95	0.73	1.63	-1.80
Growing Degree Days (base 50°F)	245	468	580	553	447
Departure from normal	47	-7	-60	-28	129

Based on weather data from a Davis Instruments Vantage Pro2 with WeatherLink data logger. Alburgh precipitation data from August-October was provided by the NOAA data for Highgate, VT. Historical averages are for 30 years of NOAA data (1981-2010) from Burlington, VT.

Throughout the growing season, temperature and precipitation fluctuated away from the 30-year historical averages. May-August was wetter than normal, receiving 4.99 more inches of precipitation as compared to historical averages (Table 4). Temperatures in May-August were cooler normal by an average of 1° F per month. September was unseasonably warm and dry, averaging 3.76°F warmer and 1.80 fewer inches of precipitation. Overall, there were an accumulated 2293 Growing Degree Days (GDDs) this season, approximately 81 more than the historical average, however, much of this heat gain came at the end of the season.

Table 5. The impact of variety on plot characteristics and harvest yield of industrial grain hemp, Alburgh, VT, 2017.

Variety	Early season vigor†	Height @ harvest	Population	Yield	Test weight	Moisture @ harvest
	1 to 5 rating	cm	plants m^2	lbs ac^{-1}	lbs bu^{-1}	%
Anka	3.25	121*	66.5	683	38.3	11.6
Canda	4.25	116*	15.5	392	36.3	11.4
CFX-2	3.50	100.0	77.3	180	41.9*	12.5
CRS-1	2.75*	90.0	74.2	478	37.7	12.0
Delores	3.50	116*	47.9	545	39.6*	12.9
Fedora 17	3.00*	**146***	61.9	832	40.4*	12.5
Full sun	2.50*	125*	85.1	534	**42.4***	13.9
Grandi	4.00	72.8	66.5	685	41.2*	12.3
Helena	3.75	120*	52.6	837	39.5*	11.9
Katani	3.75	144*	65.0	687	41.4*	11.7
Tygra	**2.00***	114	**124**	797	39.5*	12.0
USO-31	4.25	129*	74.2	335	38.3	14.1
LSD (0.10)	1.13	30.9	29.7	NS	3.26	NS
Trial mean	3.38	116	67.5	582	39.7	12.4

†Early season vigor was rated on a 1 to 5 scale with 1 = high vigor and 5 = low vigor.
*Treatments marked with an asterisk did not perform statistically worse than the top performing treatment (p=0.10) shown in **bold.**
NS – There was no statistical difference between treatments in a particular column (p=0.10).

There were no significant yield differences between varieties. Interestingly, there was some overlap between the varieties that performed the best for vigor, height, and population (Table 5). Tygra performed the best for early season vigor and was a top performer for population, which suggests that the early season advantage may have helped with establishment. Fedora and Full sun were top performers for vigor and height. Other top performers for height were Anka, Canda, Delores, Helena, Katani, and USO-31. CRS-1 was another top performer for vigor. Eight of the twelve varieties evaluated performed comparably well for test weight. Variation in test weight may be due to weed seed, plant chaff, and plant stem residues that were not removed from the hemp seed during threshing.

Table 6. The impact of variety on disease and arthropod presence in industrial hemp at female flower development (12-Jul), Alburgh, VT, 2017.

Variety	Sclerotinia infection	Aphids	Tarnished plant bug	Physical damage
	% of plants	# plant^{-1}	# plant^{-1}	# plant^{-1}†
Anka	0.000	0.350*	0.150	0.550
Canda	0.000	1.40	0.100	0.300
CFX-2	0.000	0.500*	0.100	0.200
CRS-1	0.000	0.450*	0.200	0.300
Delores	0.000	1.00	0.200	0.100
Fedora 17	0.000	0.550*	0.100	0.450
Full sun	0.000	0.450*	0.000	0.350
Grandi	0.044	0.500*	0.150	0.050
Helena	0.000	0.650*	0.100	0.250
Katani	0.054	0.650*	0.150	0.300
Tygra	0.000	0.250*	0.050	0.200
USO-31	0.000	**0.150***	0.000	0.500
LSD (0.10)	NS	0.596	NS	NS
Trial mean	0.008	0.296	3.73	0.071

†Physical damage from insect pests was recorded as the average number of damaged leaves per plant.
*Treatments marked with an asterisk did not perform statistically worse than the top performing treatment (p=0.10) shown in **bold**.
NS – There was no statistical difference between treatments in a particular column (p=0.10).

At the female flower development stage, pest pressure was minimal (Table 6). Aphids and tarnished plant bugs were present in very low populations. Ten of the twelve varieties had comparable levels of aphid infestation, however, Canda and Delores had significantly higher populations. Insect pest physical damage *Sclerotinia sclerotiorum* infection (Image 1) was also very low and not significantly different between varieties. No leafhoppers were recorded.

Image 1. *Sclerotinia sclerotium* infection on industrial hemp, Alburgh, VT, 2016.

Table 7. The impact of variety on disease and arthropod presence in industrial hemp at harvest (12-Sep), Alburgh, VT, 2017.

Variety	Sclerotinia infection	Aphids	Leafhopper
	% of plants	# plant^{-1}	# plant^{-1}
Anka	1.07*	1.40*	0.000
Canda	0.609*	**0.900***	0.000
CFX-2	3.88	3.55*	0.000
CRS-1	1.42	8.25	0.000
Delores	0.822*	2.25*	0.000
Fedora 17	0.704*	4.90*	0.000
Full sun	0.746*	2.65*	0.000
Grandi	1.05*	3.20*	0.000
Helena	**0.062***	11.9	0.050
Katani	0.483*	2.00*	0.000
Tygra	0.275*	2.30*	0.000
USO-31	0.511*	1.50*	0.000
LSD (0.10)	1.66	6.38	NS
Trial mean	0.969	3.73	0.004

*Treatments marked with an asterisk did not perform statistically worse than the top performing treatment (p=0.10) shown **bold**.
NS – There was no statistical difference between treatments in a particular column (p=0.10).

Prior to harvest, *Sclerotinia sclerotiorum* infection increased (Table 7). All varieties showed comparable levels of infection, however, CFX-2 showed a significantly higher amount of disease in comparison. Leafhoppers were minimally present. Aphids were present in greater populations than during the female flower development stage and 10 of the varieties performed comparably, while CRS-1 and Helena had a statistically significantly higher presence of aphids. There were no signs of tarnished plant bugs or physical insect pest damage.

DISCUSSION

Yield and Quality

All hemp varieties reached full plant maturity. Generally, the male flowers (pollen source) appeared after 40 days and late season varieties matured by 55 days after planting. Seed development began after 65 days and up to 75 days after planting, for the late season varieties.

The hemp was harvested on time, when plants were still young and green and seed was 50 to 70% ripe and seed moisture was within the acceptable range of 10-20% moisture. As recommended from growing hemp in Saskatchewan, Canada, hemp harvest can begin when field moisture is at 20% and plants are relatively pliable and less likely to get wrapped in the combine. However, seed would need to start drying within 4 hours as it otherwise will heat up. Seed should be dried to 8-10% moisture for long term storage. Ideally, hemp is harvested in the 12-15% range.

Average yield across all twelve varieties was 582 lbs ac^{-1} and was in the low range compared to average yields from Canada, which range from 500-1200 lbs ac^{-1}. Low yields were likely due to poor seed stands exacerbated by cool and wet weather. Unfortunately, the unseasonably cool, wet spring conditions experienced in the Northeast led to seed rot, stunted growth, and weak seedling establishment. Across all varieties, the average population was 67.5 plants m^{-2}, which was much lower than the target population of 125 plants m^{-2}. Poor early season establishment encourages the need to evaluate strategies to improve germination and early season vigor (i.e. seed treatments, seeding rates, starter fertilizers). Weed pressure was high due to the combination of poor stands along with cool temperatures that led to poor growth in the hemp crop.

Because weed pressure was high, weed seed and plant material was harvested along with the hemp seed. In spite of threshing, weed seed, chaff, and plant stems residues remained in the harvest, which affected the test weight. None of the treatments in the trial met the standard test weight for hemp of 44 lbs bu^{-1}.

The differences in height may be of special interest for farmers who would like to grow these varieties for both grain and fiber production. A taller variety may be more advantageous for fiber production; however, it may leave more possibility for lodging and wrapping in the combine. All varieties used in this trial are dual purpose cultivars for both fiber and grain use, except for Fedora 17, Full Sun, Grandi, Katani, and USO 31, which are intended for grain production only.

Pest Pressure in Hemp: Disease, insects, weeds

Hemp has the potential to host a number of diseases and insects. For the most part, hemp growing regions have not indicated that disease and arthropod pests are of economic significance. During the growing season, a survey of pest incidence was conducted to gain a better understanding of any pressures that exist on hemp in the region.

Early in the season, lesions on hemp leaves were noticed and later identified as being *Alternaria* spp., *Aspergillus* spp., and *Cladosporium* spp. These diseases did not appear to negatively affect yields. Aphids infested the hemp more heavily during later stages of plant development and did not seem to affect plant yields, since most vegetative growth had already been completed. Similarly, *Sclerotinia sclerotiorum* infection increased later in the season, but did not seem to affect yields.

During the early growth stages of hemp, plants were small, weak, and had poor root development while weeds quickly grew. In the 2016 hemp trials, about one month after planting, the hemp grew rapidly and successfully gained over the weeds without any weed control. However, due to low populations and stand establishment in 2017, the hemp was a poor competitor against the weeds. The primary weeds observed in the hemp trials were lamb’s quarter, ragweed, and foxtail. Currently, there are no pesticides (herbicides, insecticides, fungicides, nematicides, etc.) registered for hemp in the U.S, so growers must follow best practices to reduce the impact of pests, especially weeds.

It is important to remember that these data represent only one year of research, and in only one location. More data should be considered before making agronomic management decisions. It was clear that due to unseasonably cool, wet, early season conditions, all varieties underperformed. Additional research needs to be conducted to evaluate varieties under more growing conditions.

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